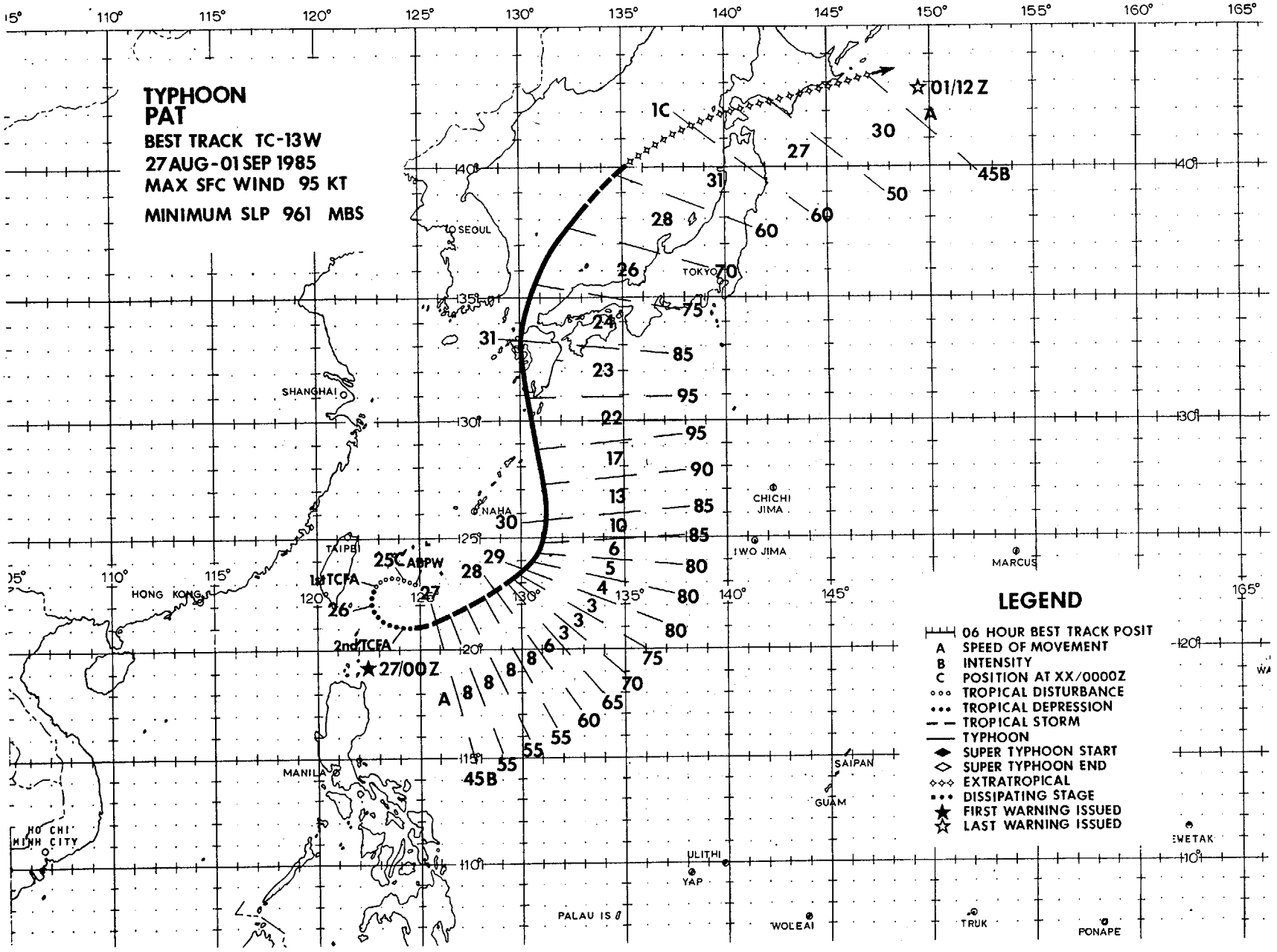
TYPHOON
PAT
BEST TRACK TC-13W
27 AUG - 01 SEP 1985
MAX SFC WIND 95 KT
MINIMUM SLP 961 MBS
01/12 Z
1C
A
30
27
45B
50
31
28
60
60
26
70
24
75
31
85
23
95
22
95
17
90
13
85
10
85
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3
3
3
75
70
65
60
55
55
55
45B
8
8
8
6
A
25C ABPW
1st TCFA
2nd TCFA
27/00Z
26
29
28
27
30
SEOUL
TOKYO
SHANGHAI
NAHA
TAIPEI
HONG KONG
MANILA
HO CHI MINH CITY
CHICHI JIMA
IWO JIMA
MARCUS
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
EWETAK
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED

Typhoon Pat developed east of Taiwan in the monsoon trough a few days after Typhoon Odessa and one day before Tropical Storm Ruby. Pat was significant due to the complex forecasting problems it caused and the damage it inflicted in Japan. The presence of two other storms (Odessa and Ruby) presented a variety of possible forecast interactions. The movement of each cyclone had to be considered in combination with the changing synoptic pattern.

The monsoon trough remained quite active the last two weeks of August. The disturbance which eventually evolved into Pat, originated in the wake of Typhoon Nelson as it moved into eastern China. The 241900Z Significant Tropical Weather Advisory (ABPW PGTW) first identified this disturbance as an area of enhanced convection in the monsoon trough. The convergence in the southwest monsoon flow combined with upper-level divergence provided an environment favorable for continued development.

The first Tropical Cyclone Formation Alert (TCFA) was issued at 251530Z when synoptic data indicated the minimum sea-level pressure (MSLP) had dropped to 1002 mb and winds of 25 kt (13 m/s) were present. An aircraft reconnaissance mission flew to investigate the region on the 26th. Although it was unable to locate a circulation, the data collected indicated the disturbance was developing - the MSLP had fallen to 999 mb and 40 kt (21 m/s) winds were observed on the south side of the monsoon trough. As a result, the TCFA was renewed at 261530Z. Figure 3-13-1 shows the active monsoon trough at this time. The disturbance is visible on the western side of the imagery with Typhoon Odessa further to the east.

Aircraft reconnaissance early on the 27th located the circulation center, prompting issuance of the first warning, valid at 270000Z. By this time

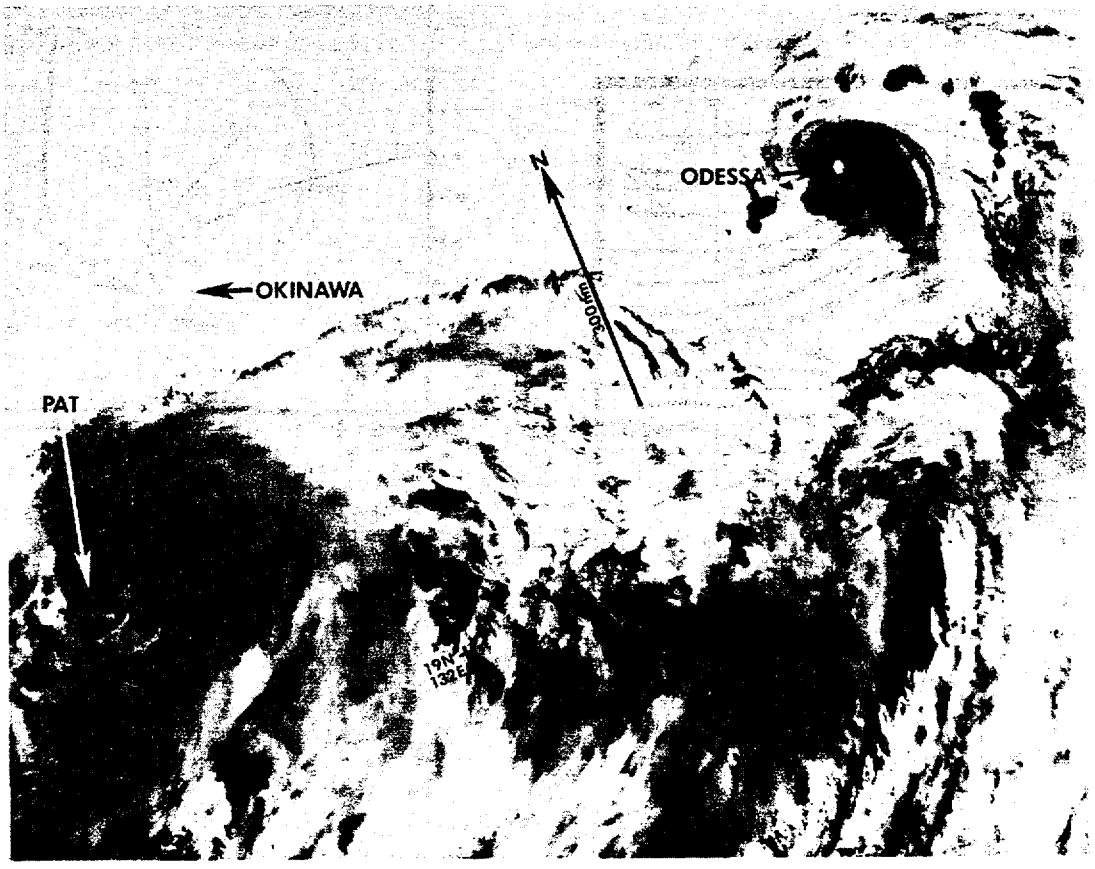
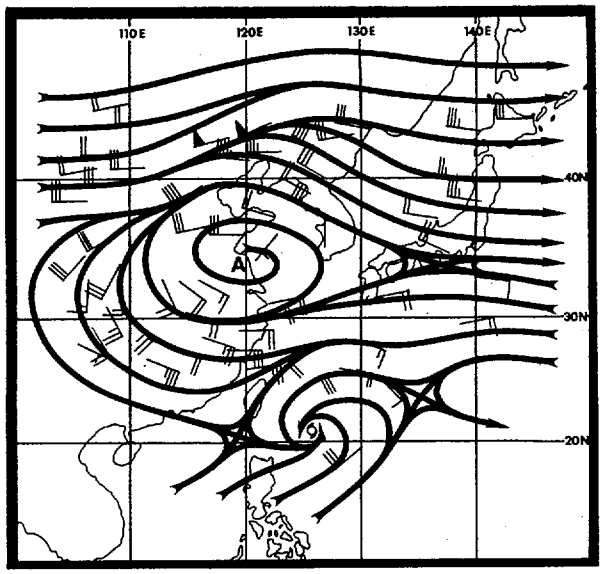


Figure 3-13-1. The tropical disturbance which became Typhoon Pat is visible as an organized area of convection in the monsoon trough. (Typhoon Odessa can also be seen) (261328Z August DMSP infrared imagery).

Pat, due to the enhanced southwesterly monsoon flow, already was at tropical storm intensity. As mentioned earlier, a large number of different factors needed to be taken into account in Pat's forecast.

Determining the direction of the track was the first problem. Because the cyclone was poorly defined on satellite imagery and as a consequence difficult to position, Pat was believed to be moving west-northwest for the first two warnings, when it was actually moving east-northeast. This was critical since persistence from past movement is often a major forecast consideration, especially in the short term forecasts. Figures 3-13-2 and 3-13-3 show some of the data available to the forecasters. A streamline analysis of the 270000Z August 500 mb data has been completed in Figure 3-13-2 to show the location of the subtropical ridge north of Pat. Figure 3-13-3 depicts the first set of forecast aids, using the east-northeast persistence track as a basis, along with the forecast and best track. The most striking feature is, that despite a lot of different options provided by the aids, none really hit the mark at seventy-two hours.

Figure 3-13-2. Mid-tropospheric (500 mb) wind flow at 270000Z August. The dominant synoptic feature is the subtropical ridge extending across China and Japan to the north of Pat.



hit the mark at seventy-two hours.

The forecast called for Pat to move along the monsoon trough to the east-northeast; separate from the trough, and turn back to the west-northwest under the subtropical ridge. This was in reasonable agreement with the One-way Interactive Tropical Cyclone Model (OTCM) model which is usually the best performing forecast aid. The Fleet Numerical Oceanography Center (FNOC) 72-hour 500 mb Navy Operational Global Atmospheric Prediction System (NOGAPS) prognosis called for the ridge to weaken as a trough moved eastward across Mongolia. It appeared, however, that the ridge would remain strong enough to keep Pat south and west of Japan. As it turned out, the prognosis was slow on the movement of the trough, which resulted in the ridge weakening over western Japan.

For the rest of the 27th and all of the 28th, Pat remained in the monsoon trough and continued drifting to the northeast. The forecast situation was further complicated by the presence of Typhoon

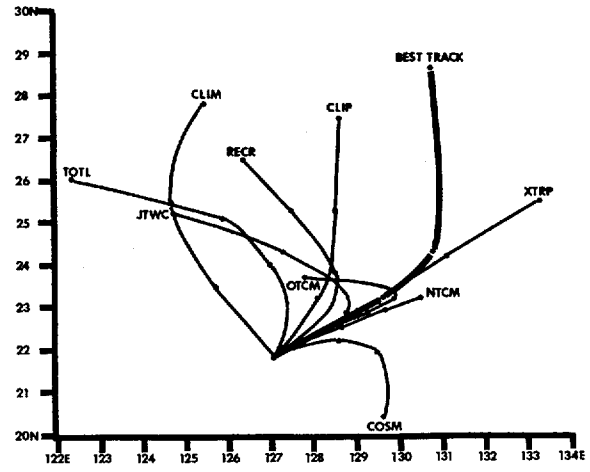


Figure 3-13-3. The primary forecast aids at 271200Z, along with the forecast and post analysis best track; all valid for 72-hours. None of the aids are able to provide correct guidance at seventy-two hours.

Odessa and Tropical Storm Ruby. Figure 3-13-4 shows Pat on the 28th - Odessa and Ruby are also visible. Despite the three cyclones being so close, each was moving a different direction. Pat was moving northeastward, Odessa west, and Ruby north-northwest. According to the OTCM, Pat should stay under the ridge. The forecast reflected this guidance and continued to show a turn to the northwest.

The 290600Z OTCM was the first to suggest a track change for Pat, taking it around the ridge and into the Sea of Japan. In analyzing this change, the presence of Odessa was closely examined. Odessa was moving west and located only 380 nm (704 km) north-northeast of Pat. The OTCM, however, had Odessa moving north into the Sea of Japan, despite the fact Odessa was continuing to move westward under the ridge.

On the 29th, the OTCM guidance was rejected and Pat was forecast to turn to the northwest. It was believed that the ridge over Japan was too narrow for the OTCM to pick up with its relatively large grid spacing. The fact that the OTCM was consistently wrong with Odessa reinforced this belief. In post analysis, however, it is believed Odessa kept moving

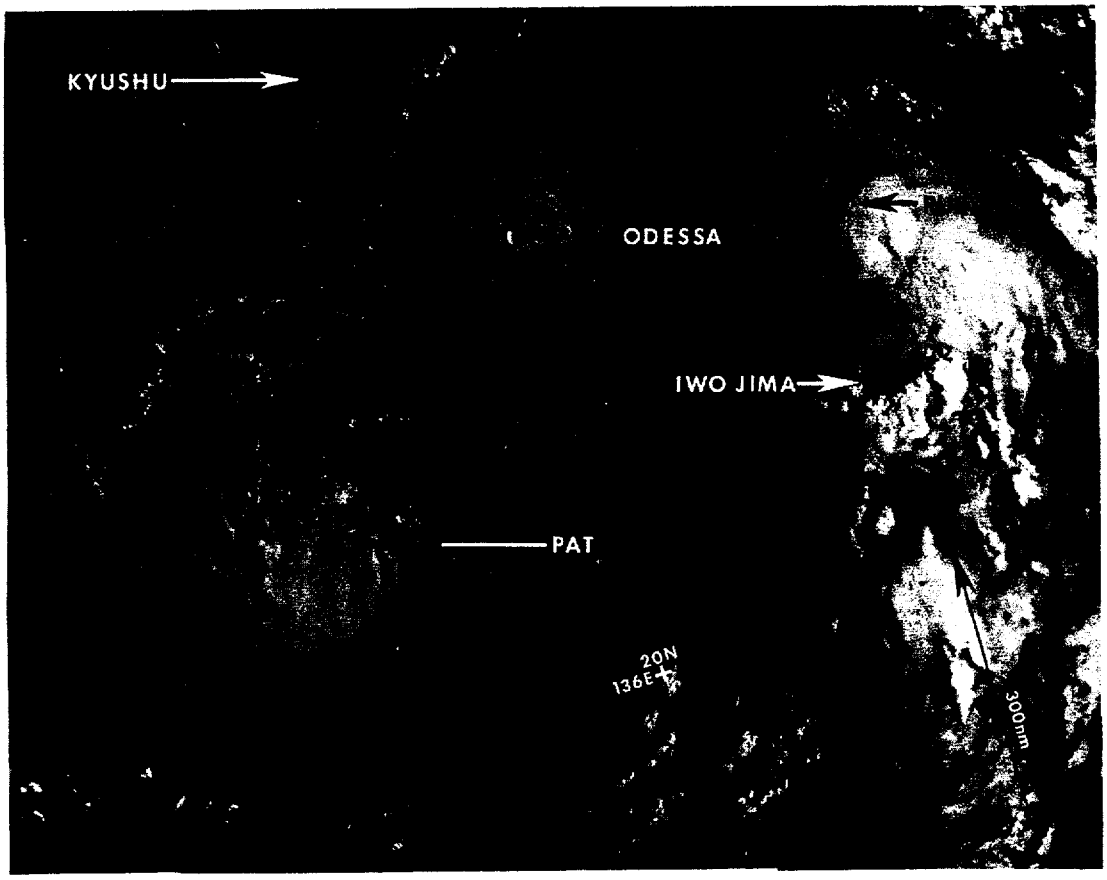


Figure 3-13-4. Three active tropical cyclones south of Japan and all moving different directions. Typhoon Pat is heading northeast, Typhoon Odessa is heading west, and Tropical Storm Ruby is heading north-northwest (282303Z August NOAA visual imagery).

westward at this stage due to binary interaction with Pat rather than from a response to the ridge. Visual satellite imagery early on the 30th (Figure 3-13-5) shows the two were spatially proximate. It is reasonable to believe that if Pat had been the only tropical cyclone in the region at this time, the forecast probably would have been changed on the 29th rather than on the 30th; providing Japan an additional 24 hours of warning time.

With the additional data received on the 30th, it became evident that Pat was not responding to the steering flow of the ridge and was going to hit the Japanese island of Kyushu. The 301200Z forecast was the first to reflect this change. Figure 3-13-6 shows the 500 mb data available at that time. When comparing it with Figure 3-13-2, it is evident that major synoptic changes took place in seventy-two hours. The anticyclone over the China coast was gone and a trough was located just northwest of the Korean Peninsula.

An in-depth look at the interaction between Pat and Odessa, revealed the two typhoons rotated cyclonically around each other. The affect on Odessa's track was greater, however, since Pat was the larger system. Odessa kept moving westward, aided by interaction with Pat. It was interesting to note that Pat did not turn to the north and accelerate until Odessa rotated across to the north-northwest. Then, as soon as Pat was east-northeast of Odessa, Odessa turned to the northeast and both cyclones accelerated into the Sea of Japan. The closest point of approach between the two was 270 nm (500 km).

At that point, the forecast was straightforward with extratropical transition taking place in the Sea of Japan. Figure 3-13-7 shows Pat during its transition with stable stratocumulus clouds present around a large open center and convection limited to the northeast quadrant. Pat completed extratropical transition at approximately 312100Z. The warnings continued warning on the system until it moved across the island of Hokkaido in northeastern Japan. The final warning was issued at 011200Z.

Typhoon Pat caused significant damage in southwestern and northeastern Japan; primarily on the islands on Kyushu and Hokkaido. Kyushu was hit the hardest with wind gusts of 107 kt (55 m/s) reported at 301940Z in Kagoshima (WMO 47851). Misawa AB (WMO 47580) recorded sustained winds of 33 kt (17 m/s) with a peak gust to 52 kt (27 m/s) at 010710Z when extratropical remnants of Pat crossed the northern Japanese islands. A total of 23 people were reported killed with over 180 people injured. An estimated 3,000 homes were damaged and 148 watercraft of varying sizes lost. Pat also severely disrupted transportation by land, sea and air.

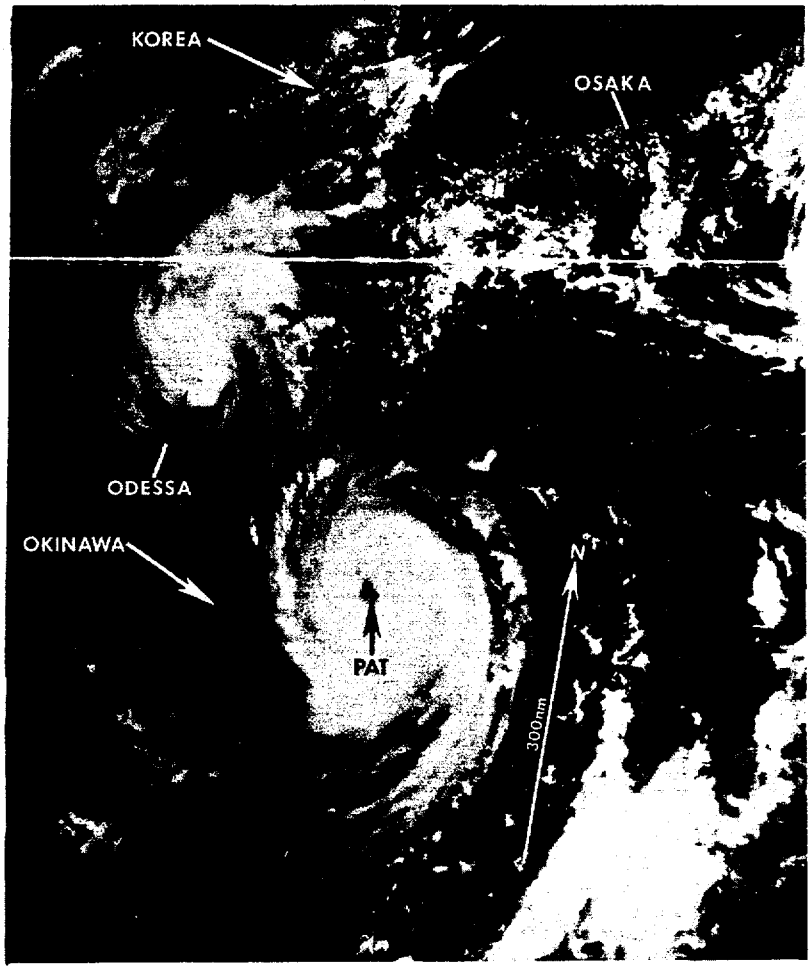


Figure 3-13-5. Typhoon Pat moving northward towards Kyushu and interacting with Typhoon Odessa. Pat is the larger of the two typhoons (300538Z August NOAA visual imagery).

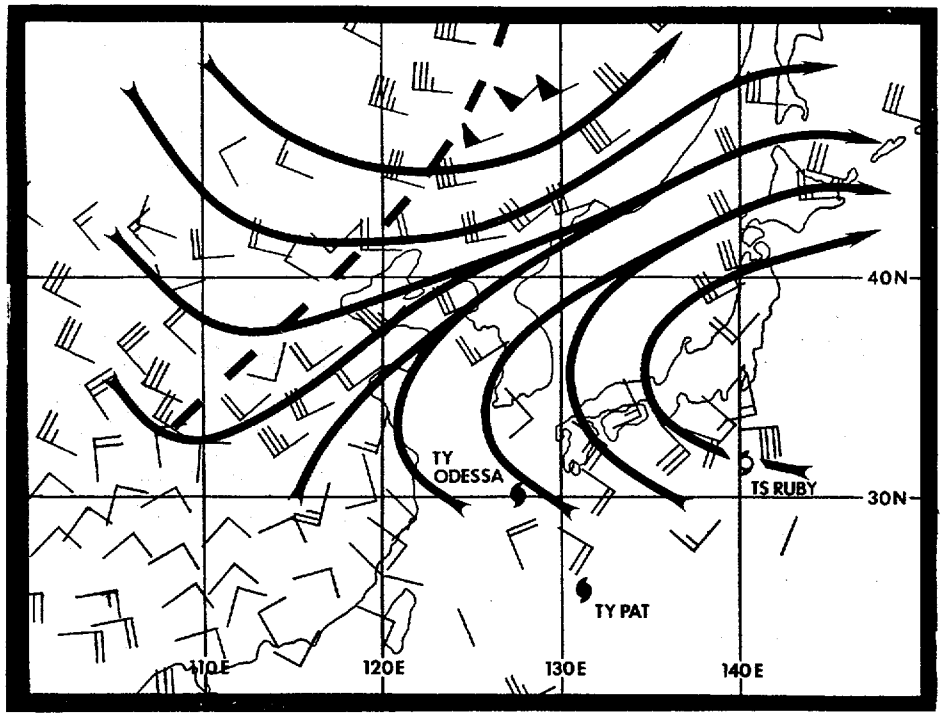


Figure 3-13-6. Mid-tropospheric (500 mb) wind flow at 300000Z August seventy-two hours after Figure 3-13-2. The anticyclone over the coast of China is gone and a trough is moving into the region from the northwest.

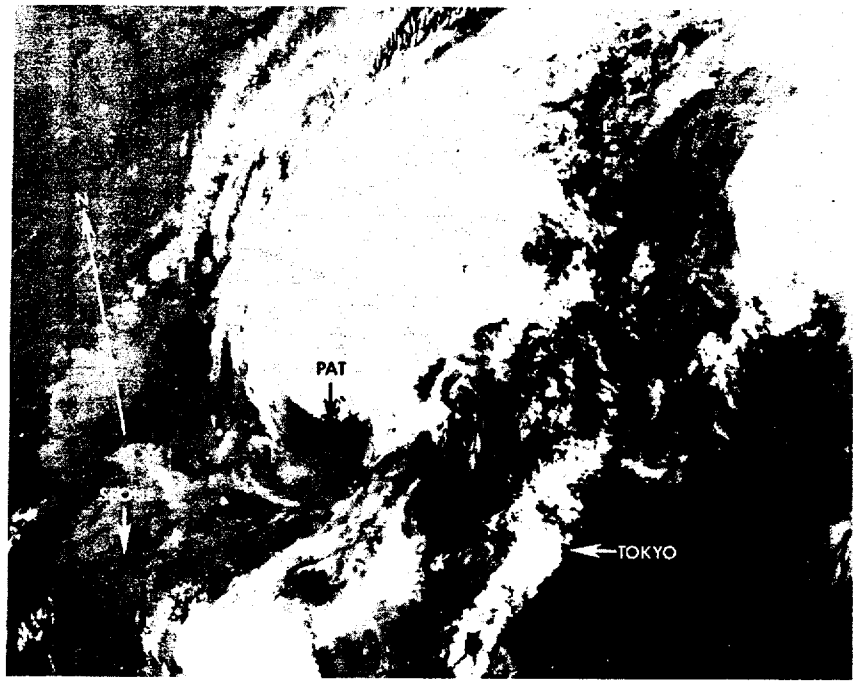


Figure 3-13-7. Pat has nearly completed its transition to an extratropical low in the Sea of Japan. The convection is moving to the northeast leaving behind a broad, exposed low-level circulation center (311813Z August NOAA infrared imagery).